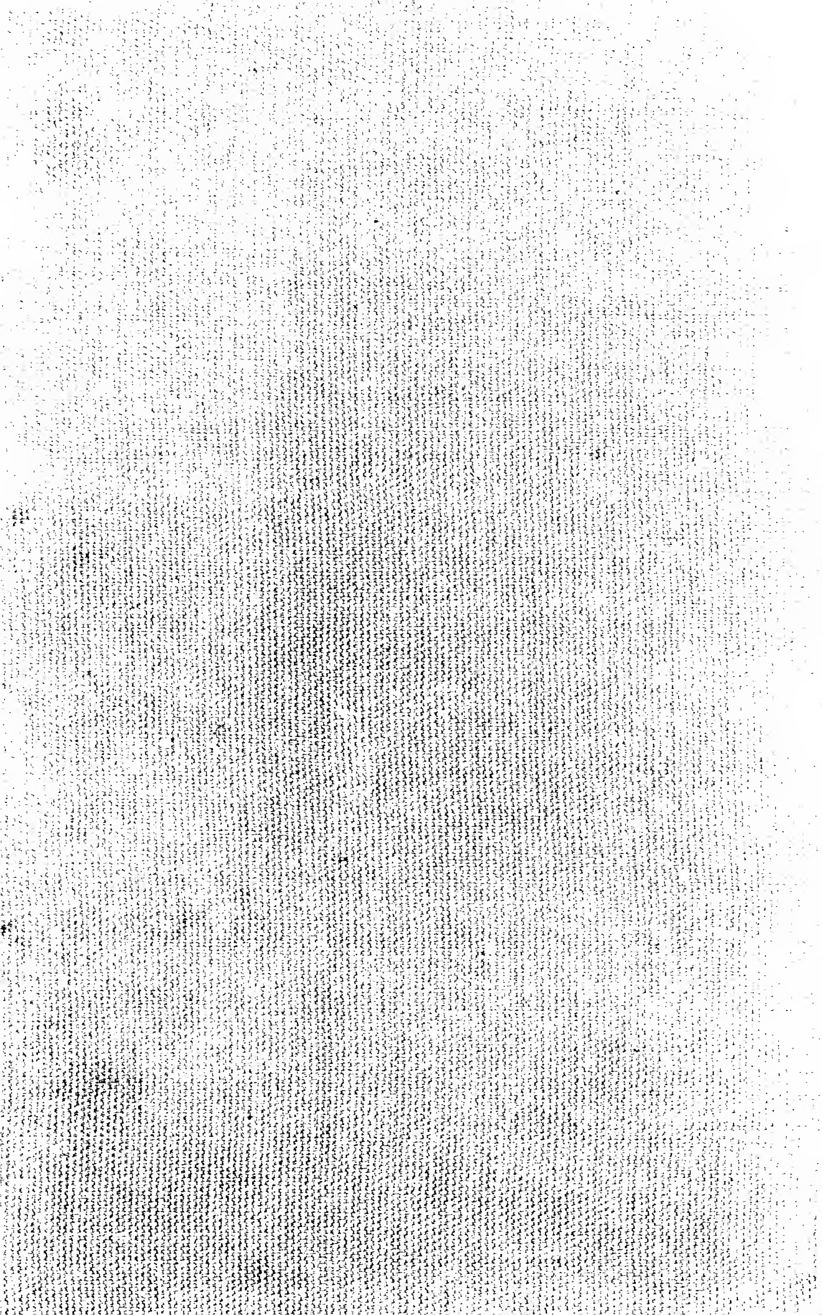

NEW HAMPSHIRE

AGRICULTURAL

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HANOVER, N. H.,

BULLETIN NO. 12.

FERTILIZER EXPERIMENTS.

MARCH, 1891.

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OF THE

NEW HAMPSHIRE

Agricultural Experiment Station.

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FERTILIZER EXPERIMENTS.

The fertilizer experiments for the season of 1890 were in part a continuation of similar work, which has been reported on before, and in part a new line of work, relating more especially to the use of manures, prepared fertilizers, chemicals and ashes on a crop of ensilage corn; I am convinced that there is room for a considerable saving in the purchase of *plant food*, as well as a possibility of more economical uses of manures, and I can only hope that the suggestions given, and the conclusions drawn from the work, will be thoroughly tested by the farmers of the State, for they are of use and value only as they are put to the test on various soils and under existing conditions. Unless tried they are of no value to those for whom the work has been and is being done.

From those who have tested the merits of the combinations first sent out from this College in 1885, and not materially modified since that time, there is testimony that convinces me that the general combination recommended for corn is substantially what is required for our soils, and from Massachusetts and Vermont I receive similar testimony, but while every new test adds to the probability of the correctness of my position relative to the need of vastly more potash than our fertilizer manufacturers give us, yet farmers must in the end satisfy themselves by trial on their own soil; and there is no possibility of loss resulting from this trial with every probability of gain.

TABLE I.

		No. of Plot.																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Kind of Fertilizer.		bu.	lbs.	lbs.	lbs.	lbs.		lbs.	lbs.	lbs.	lbs.	bu.		lbs.	lbs.	lbs.	lbs.		lbs.	lbs.	lbs.
	Dissolved bone-black,		18½	24¼	14	....	Nothing.			17½	16½		Nothing.	16½		18½	10½	Nothing.	....	...	32½
	Muriate of potash,		3⅔	6	....	17¼				8¾	5			5		3⅔	9½		...	22¼	....
	Sulphate of Ammonia,		3⅔	....	7¼	2¾				1	3½			3½		3⅔	3¼		12½	....	....
	Ashes,											2									
	Manure,	35																			
	Stockbridge,							26													
	Bowker, Hill and Drill,														28						
	Bradley, XL,								26												
Analyses.	Phosphoric acid, %	.23	11.4	12 8	10.5	....	....	10.7	11.8	10.5	10 5	1.5	....	10.5	12.4	11.4	7.2	....	....	....	16
	Potash, %	.48	7.0	10.0	....	43 5	....	5.0	2.1	16.0	10.0	6.5	....	10.0	2.0	7.0	20.4	....	....	50	
	Nitrogen, %	.48	2.8	....	6.8	2.8	....	4.0	2.5	0.7	2.8	....	....	2.8	2.5	2.8	2.8	....	20	....	

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TABLE II.

	No. of Plot.																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Yield in bushels per acre,	238	224	206	114	132	96	194	150	190	234	130	94	186	190	204	220	92	90	124	124
Gain over average of plots with no fertilizer, bu.,	144	130	112	20	38	....	100	56	96	140	36		92	96	110	126		—4	30	30
Value of crop, @ 50 cents per bushel, $	119	112	103	57	66	48	97	75	95	117	65	47	93	95	102	110	46	45	62	62
Value of gain over plots with no fertilizer, $	72	65	56	10	19		50	28	48	70	18		46	48	55	63			15	15
Value of gain for $1.00 invested in fertilizer, $	3.60	6.50	5.60	1.00	1.90		5.00	2.80	4.80	7.00	1.80		4.60	4.80	5.50	6.30			1.50	1.50

The co-operative work carried on in 1889 was not continued, except in a single case, as there are few who are willing to devote the necessary time and trouble to the laying out of plots, and more especially to the weighing of the harvested crop. The exception above noted was a series of tests on *potatoes*, carried on by Mr. S. B. Whittemore, of Colebrook, in the heart of the potato region of New Hampshire, and the results are of interest and value to every man who contemplates purchasing fertilizers for use on this crop.

The combinations of chemicals were the same as those sent out in 1889, and in the following table is given the kind and amount of each chemical used per plot of one-twentieth acre, and also the chemical composition of the mixed fertilizer as it would have shown by chemical analysis:

It will be seen from this table that each form of plant food is used by itself (see Plots 18, 19, 20), also in combinations of two with the third omitted (see Plots 3, 4, 5), and in addition to these the three forms are combined in varying proportions (see Plots 2, 9, 10, 13, 15, 16). Plots 2 and 15 are duplicates, as are 10 and 13.

The Station mixed and sent out all the chemicals, and also the prepared fertilizer, for Plot 14, using an amount on each plot which would, at the prices then asked, cost ten dollars per acre. The prepared fertilizers used on Plots 7 and 8 were selected by Mr. Whittemore from the local market, and whether the cost was more or less than ten dollars per acre I am unable to say; it is probable, however, that two pounds more of Bradley's XL should have been used, as its selling price is usually the same as that of Bowker's H & D. Two bushels of ashes were used on the supposition that they cost twenty-five cents per bushel, which is the average price for unleached ashes, and thirty-five bushels of manure were selected because that amount would give what our farmers consider a good dressing, namely, seven cords, or twenty loads, per acre, the cost of this, however, would be twice the cost of the fertilizer used on the other plots, and this fact must be kept in mind in comparing results. All the other plots are directly comparable, since there was equal outlay on each.

The lower division of Table I shows the chemical analysis of each form of fertilizer. In the case of the manures and ashes the average of many analyses is taken, and for the prepared fertilizer the average as determined by the Station from samples collected by the Secretary of the Board of Agriculture.

Table II *gives the yields per acre*, the value of this yield at fifty cents per bushel; also the gain over the average of the four plots with no fertilizer; and the value of the gain due to a dollar's worth of fertilizer of each kind.

That the land on which these experiments were carried on was of uniform quality to start with is shown by the yield of the plots with no fertilizer, these plots being scattered about over the acre:

No. 6, no fertilizer,	96 bushels
No. 12, "	94 "
No. 17, "	92 "
Average,	94 "

(Series 1.) SINGLE ELEMENTS OF PLANT FOOD.

Plots 18, 19, 20, show what each of the forms of *deficient plant food* were able to produce on this soil: Nitrogen alone, in the form of sulphate of ammonia, yielded ninety bushels, an actual loss over plots with no fertilizer; Potash alone, in the form of muriate, yielded one hundred and twenty-four bushels; Phosphoric acid alone, in the form of dissolved bone-black, yielded one hundred and twenty-four bushels. A gain in each case of thirty bushels.

So far as this series is concerned, we should be justified in concluding that nitrogen was of no use, and that potash and phosphoric acid are of equal importance, but I wish to express my belief that these tests with *only one form of plant food* are of very little if any use, but as they are a part of almost every scheme of soil testing I have always put in a set, more to conform to the common custom than from any idea that they would teach anything of much importance.

(Series 2.) COMBINATIONS OF TWO ELEMENTS OF DEFICIENT PLANT FOOD.

Plots 3, 4, 5 were designed to show whether either of the three nutritive elements could be dispensed with.

Plot 3, furnished with phosphoric acid and potash, yielded 206 bushels.

Plot 4, furnished with phosphoric acid and nitrogen, yielded 114 bushels.

Plot 5, furnished with potash and nitrogen, yielded 132 bushels.

So far as this series of plots is concerned we have evidence that nitrogen is of the least importance, potash of the most, and phosphoric acid intermediate, and it is clearly the case that phosphoric acid and potash combined give a good crop, well up towards the complete mixtures.

Combining the evidence from Series 1 and 2 and we get the following:

Group	Plot	Fertilizer	Amount Per acre. lbs.	Yield Per acre. bu.
(*a*)	Plot 20.	Dissolved bone black,	666	124
	Plot 4.	Dissolved bone-black, Sulphate of Ammonia,	280 145	114
	Plot 3.	Dissolved bone-black, Muriate of potash,	485 125	206
(*b*)	Plot 19.	Muriate of potash,	445	124
	Plot 5.	Muriate of potash, Sulphate of ammonia,	345 55	132
	Plot 3.	Muriate of potash, Dissolved bone-black,	125 485	206
(*c*)	Plot 18.	Sulphate of ammonia,	250	90
	Plot 4.	Sulphate of ammonia, Dissolved bone black,	145 280	114
	Plot 5.	Sulphate of ammonia, Muriate of potash,	55 345	132

Group (*a*), Plot 4, shows that substituting 145 lbs. of sulphate of ammonia for 386 lbs. of the dissolved bone-black, in Plot 20, decreases the yield 10 bushels; but in Plot 3, substituting 125 lbs. of muriate of potash for 181 lbs. of the dissolved bone-black gives an increase of 82 bushels.

In group (*b*), Plot 5, the substitution of 55 lbs. of sulphate of ammonia for 100 lbs. of the muriate of potash in Plot 19, increases the yield 8 bushels; while in Plot 3, replacing 320 lbs. of the muriate of potash in Plot 19, with 485 lbs. of dissolved bone-black increases the yield 82 bushels.

Group (*c*) shows that replacing 105 lbs. of sulphate of ammonia with 280 lbs. dissolved bone-black added to the yield 24

bushels; and that when 195 lbs. of sulphate of ammonia were replaced by 345 lbs. of muriate of potash the increase was 42 bushels.

The three groups show that the greatest yield comes from phosphoric acid and potash, (Plot 3); the next best from nitrogen and potash, (Plot 5); the next from phosphoric acid alone, (Plot 20), and from potash alone, (Plot 19); the next from phosphoric acid and nitrogen, (Plot 4); and the poorest from nitrogen alone, (Plot 18).

(Series 3.) COMPLETE CHEMICALS.

In this series three elements of plant food are combined in various ways, the object being to form some idea of the "crop ration" best suited to the conditions of this soil for the potato crop; to this end the method suggested in Bulletin No. 6 of this Station, p. 15, was practiced, and in plots 2, 9, 10, 13, 15, and 16, we have combinations of the three fertilizing chemicals which cost the same per acre, but which differ very materially in the proportion of their parts as the per cent of phosphoric acid, potash and nitrogen, given in Table 1, will show.

Plots.	Analysis.			Yield per acre.
	*P_2O_5.	K_2O.	N.	bu.
(*d*) 2 and 15,	11.4	7	2.8	214
(*e*) 10 and 13,	10.5	10	2.8	210
(*f*) 16,	7.2	20.4	2.8	220
(*g*) 9,	10.5	16	0.7	190

Group (*e*) differs from (*d*) by decreasing the per cent of phosphoric acid and increasing the per cent of potash. So far as the *average* is concerned the yield was slightly decreased by the exchange, but it will be observed that there is a wide difference in the yield of the plots 10 and 13. The cause of this is unknown to me, and while I feel sure that there was some local circumstance which seriously affected plot 13, yet I have averaged it with its duplicate. As a matter of fact, however, I have no doubt but that the yield from group (*e*) should have been much nearer that of plot 10.

On Plot 16, however, where still further reduction of phos-

*P_2O_5 means phosphoric acid; K_2O means potash; N means nitrogen.

phoric acid was made and potash increased, the yield was somewhat increased.

Plot 9 is comparable with group (*e*), the object was to decrease the nitrogen and increase the potash; this change caused a very decided loss.

Taking these plots together we may fairly infer that 7.2 per cent of phosphoric acid is ample for the soil under consideration; that 20.4 per cent of potash is better than 7, and that 0.7 per cent of nitrogen is not enough.

There is other evidence that shows that some nitrogen is needed.

Take the following plots:

	P_2O_5.	K_2O.	N.	
9,	10.5	16	0.7	yields 190
10 and 13,	10.5	10	2.[illegible]	" 210
3,	12.8	10	0	" 206

Now, if we remember, that plots 10 and 13 should, without doubt, have averaged more than 210 bushels, we shall see that the substitution of phosphoric acid in plot 3 for *all* of the nitrogen in 10 and 13 resulted in loss, and exchanging the greater part of the nitrogen for potash (see Plot 9), also resulted in loss, we must conclude, therefore, that from one to three per cent of nitrogen is needed on soils where potatoes are the first crop in a rotation, but had corn or any crop which had received manure or a nitrogenous fertilizer preceded this potato crop it is very likely true that nitrogen would not have been needed.

(Series 4). PREPARED FERTILIZERS.

This series, made up of Plots 7, 8 and 14, were designed to test the relative merit of $10.00 worth of plant food in the best mixed goods, and $10.00 worth in chemicals.

No. 7, with 26 lbs. of Stockbridge potato fertilizer, yielded 194 bushels.

No. 8, with 26 lbs. of Bradley's XL fertilizer, yielded 150 bushels.

No. 14, with 28 lbs. of Bowker's Hill and Drill fertilizer, yielded 190 bushels.

The following represents average analyses of these fertilizers:

		P_2O_5.	K_2O.	N.
Stockbridge,	%	10.7	5.0	4.0
Bradley XL,	%	11.8	2.1	2.5
Bowker H. and D.,	%	12.4	2.0	2.5

As a means of obtaining a comparative statement of the four series, I have given below a table showing the average result from each series:

Series.		Yield. bu.	Gain over no ertilizer, bu.
1.	(Single element of plant food,)	113	19
2.	(Two elements of plant food,)	150	56
3.	(Three elements of plant food,)	210	116
4.	(Prepared fertilizer,)	178	84
5.	(Ashes,)	130	36
6.	(Manure,)	238	144
7.	No fertilizer of any kind,	94	

There can be no doubt as to the relative efficiency of series 3 and 4, since the amounts used would cost the same. The thirty-two bushels increase represents an absolute gain due solely to the use of mixed chemicals in place of the best of prepared fertilizers.

The cause of the increased efficiency is easily discerned, for I assume that the prepared fertilizers above mentioned were made from good grade materials, and that the plant food, shown by analysis, was available. The following comparison of the average chemical composition of the fertilizers in each series needs little explanation.

		P_2O_5.	K_2O.	N.
Series 3.	(Complete chemicals,) %	10.2	11.7	2.5
Series 4.	(Prepared fertilizer,) %	11.6	3.0	3.0

The conclusion is fully warranted that *more potash is needed than the prepared fertilizers furnish.*

MANURE AND CHEMICALS COMPARED.

On Plot 1 manure was used, as has already been stated, at the rate of seven cords, or $20.00 worth, per acre. That is, twice as much in cost as of either of the fertilizers, and while the yield is the largest of any plot, it is only four bushels ahead of Plot 10, and if we compare the value of the gain per one dol-

lar of fertilizer, as in the last part of Table II, it will be seen that one dollar invested in manure gave only an increaes worth $3.60; while one dollar invested in complete chemicals gave an increase worth $5.80, and one dollar invested in the best combination (Plot 10) gave an increase worth $7.00, and one dollar invested in prepared fertilizer gave an increase worth $4.20.

Here are figures well worth careful consideration, and they do not stand alone, for in Bulletin No. 10 will be found the report of a duplicate series, made in 1889 by the same party, which shows the same general results, demonstrating the value of such tests when properly carried out.

For the purpose of showing the composition of the fertilizer producing the best results I have selected those giving the *three highest* yields as well as the one giving the *highest*, both from the experiments of 1889 and 1890, and have given below the chemical composition:

		1889.	1890.
Best 3 yields,	P_2O_5, %	11.6	9 7
	K_2O, %	7.1	12.4
	N, %	2.3	2.8
Best yield,	P_2O_5, %	12.8	10.5
	K_2O, %	10.0	10.0
	N, %		2.8

CONCLUSIONS.

The above results so fully confirm previous observations, that I shall simply reprint the conclusions given in Bulletin No. 10 of this Station, p. 12:

1st. Chemicals when properly mixed can fully take the place of farm yard manure as a source of plant food.

2nd. Chemicals when properly mixed can and do give greater increase of crop than commercial fertilizers.

4th. The average chemical composition of fertilizers for New Hampshire should be *Phosphoric Acid*, 9 *to* 11 *per cent*, *Potash*, 9 *to* 15 *per cent*, *Nitrogen*, 2 *to* 4 *per cent*, whereas, the fertilizers offered to us in the market, average *Phosphoric Acid*, 11 *per cent*, *Potash*, 2.5 *per cent*, *Nitrogen*, 2.5.

HOW TO GET CHEMICAL FERTILIZER.

Dissolved bone-black, containing sixteen per cent of available phosphoric acid, muriate of potash, containing fifty per cent

of actual potash and sulphate of ammonia, containing twenty per cent of nitrogen, are all of the substances required for preparing such fertilizers as will give the best results. These can be bought of any wholesale dealer in, or manufacturer of fertilizers. They are perfectly harmless substances, as easily and safely mixed as corn meal, shorts and middlings.

The quantities required per acre will, of course, vary, but from Table I, we may easily get the amount that was actually used per acre, on any given plot, by multiplying the quantities given in the table by twenty, for example:

Plot 10 gave best yield; there was used on this at the following rate per acre:

Dissolved bone-black,	330 lbs.
Muriate of potash,	100 lbs.
Sulphate of ammonia,	70 lbs.
	500 lbs.

For the third time I will reprint the combinations which have now been tested for the past five years:

CORN.

(Also for potatoes on land where no manure has been used for many years.)

Dissolved bone-black,	325 lbs.
Muriate of potash,	100 lbs.
Sulphate of ammonia,	75 lbs.
	500 lbs.

POTATOES.

(Following a manured crop.)

Dissolved bone-black,	340 lbs.
Muriate of potash,	160 lbs.
	500 lbs.

I would only ask the farmers of New Hampshire to try these combinations, even if at some trouble and extra expense, for I am certain that on by far the greater part of our soils, such mixtures will prove superior to the prepared goods as now compounded.

G. H. WHITCHER, *Director.*